MA 12: FS: Single Nanomagnets

Time: Tuesday 10:45–12:45 Location: H22

Topical Talk MA 12.1 Tue 10:45 H22

Exploring the frontiers in cluster magnetism from a theorist's perspective — •Gustavo Pastor — Institut für Theoretische Physik, Universität Kassel, Germany

In past years a remarkable progress has been achieved in the experimental synthesis and characterization of magnetic clusters, which renders increasingly rigorous comparisons between realistic (experimental) and idealized (theoretical) nanostructures possible. These investigations concern in particular magnetic phenomena that are specific to single clusters. The purpose of this talk is to discuss some of the current theoretical challenges in the theory of cluster magnetism. The specific subjects to be explored are strong electron correlation effects, finite-temperature spin fluctuations and magnetic anisotropy energy (MAE). The problem of local moment formation and Kondo effect of transition-metal impurities in finite NiCuN and CoCuN metal clusters is investigated. First principles calculations show that the Ni or Co impurities preserve their magnetic degree of freedom and are therefore good candidates for developing interesting many-body phenomena. The temperature dependence of the magnetic properties of FeN clusters ($N \leq 24$) are determined in the framework of a functional-integral itinerant-electron theory. A remarkable dependence of the average magnetic moment per atom Δ N(T) on size and structure is observed. CoRh alloy nanoparticles show non-trivial correlations between chemical and magnetic order that lead to a non-monotonous dependence of the MAE as a function of composition, yielding a perspective of tailoring the MAE of nanoalloys.

Topical Talk MA 12.2 Tue 11:15 H22

Magnetic chirality in the electron microscope: Progress and Applications — •Peter Schattschneider — Inst. F. Festkörperphysik und Univ. Serviceeinrichtung für Elektronenmikroskopie, Technische Universität Wien, A-1040 Vienna, Austria

Via the electron-electron interaction it can be shown everything that can be done in a synchrotron is also feasible in an electron microscope. In practice, however, electron and photon probes behave differently. In this respect, the EMCD technique (energy loss magnetic chiral dichroism) in the electron microscope [1] - the equivalent of the synchrotron based XMCD, a standard technique for the study of atom specific magnetism - has the intrinsic advantage of high spatial resolution. The main difficulty with EMCD is the low signal intensity, asking for exposure times of the order of minutes, and very particular scattering conditions necessary to observe a chiral dichroic signal. Nevertheless, much progress was made in the last years. EMCD has evolved into several techniques, now utilising either energy filtering, spectroscopy, TEM or STEM conditions. After a synopsis of the present situation in EMCD, recent results such as nanometric resolution, the applicability of XMCD sum rules, and new image simulation software are discussed. The observation that chiral electronic transitions break certain mirror symmetries in energy spectroscopic diffraction (ESD) led to the prediction that this chirality pertains in energy filtered high resolution imaging, thus opening a road to mapping electron spins of individual atomic columns under HR-TEM conditions. [1] P. Schattschneider et al., Nature. 441 (2006), 486.

Topical Talk MA 12.3 Tue 11:45 H22

Stochastic resonance of a nanomagnet excited by spin transfer torque — •Ilya Krivorotov — Department of Physics & Astronomy, University of California, Irvine, California 92617, USA

Spin transfer torque from spin-polarized electrical current can excite large-amplitude magnetization dynamics in metallic ferromagnets of nanoscale dimensions. Since magnetic anisotropy energies of nanomagnets are comparable to the thermal energy scale, temperature can have a profound effect on the dynamics of a nanomagnet driven by spin transfer torque. We observe unusual types of microwave-frequency nonlinear magnetization dynamics co-excited by alternating spin transfer torque and thermal fluctuations in NiFe/Cu/Co spin valves of nanoscale dimensions. In these dynamics, temperature amplifies the amplitude of GHz-range precession of magnetization and enables excitation of highly nonlinear dynamical states of magnetization by weak alternating spin transfer torque. We explain these thermally activated dynamics in terms of non-adiabatic stochastic resonance of magnetization driven by spin transfer torque. We find that the non-adiabatic stochastic resonance of magnetization gives rise to strong enhancement of the rectified voltage generated by nanoscale spin valves in response to alternating spin current, and thus this type of magnetic resonance may find use in sensitive nanometer-scale microwave signal detectors.

Topical Talk MA 12.4 Tue 12:15 H22

Exploring single nanomagnets with photoelectron microscopy — •Florian Kronast — Helmholtz-Zentrum Berlin GmbH, Albert-Einstein-Str. 15, D-12489 Berlin, Germany

Nanostructures exhibit new and interesting magnetic properties that can not be derived from bulk properties. E.g. their effective magnetization and the Curie temperature may differ dramatically from bulk values due to finite size effects. Magnetic nanoparticles with core-shell structures are likely to show different magnetic order at the surface and in the core. In ensembles of nanoparticles inter-particle interactions strongly influence their individual magnetic properties. To resolve those nanoscale effects on the appropriate length scale we investigate individual nanomagnets by means of microspectroscopy. Using photoelectron microscopy with synchrotron light excitation we can access their chemical composition, magnetic moment and orientation with 30nm lateral resolution. A built-in magnetic yoke and temperature control allows us to measure magnetic responses of individual nanoparticles to an external magnetic field of up to ± 50mT as a function of temperature. To correlate magnetic properties of individual nanomagnets with their size, chemical composition, structure, and local coordination we combine our microspectroscopy data with detailed structural information obtained by high resolution electron microscopy. Measurements on Fe nanoparticles with a cubic shape and a side length 18nm [1] demonstrate how strongly their magnetic properties vary with their local coordination and oxidation state. [1] A. Shavel et al, Adv. Funct. Mat. 17 (2007) 3870